SECTION 10

COSTS OF TECHNOLOGY BASES OF REGULATIONS

10.1 Introduction

Previous sections have described the respective BPT, BCT, BAT, NSPS, PSES, and PSNS technology options that were considered as the bases of regulations for the pharmaceutical manufacturing industry. This presents the estimated engineering costs associated with installing and operating each of these technology bases. These costs are calculated to determine the overall economic impact on the industry of complying with each regulatory option.

The following information is discussed in this section:

- 10.2 discusses the costing methodology;
- 10.3 discusses cost modeling and summarizes cost estimating assumptions and design bases of the technologies that make up the regulatory options; and
- 10.4 presents the cost estimates by regulatory option.

10.2 Costing Methodology

To accurately determine the impact of the effluent limitations guidelines and standards on the pharmaceutical manufacturing industry, it is necessary to calculate costs associated with regulatory compliance. A cost model was developed to represent each of the regulatory options under BPT, BCT, BAT, PSES, PSNS, and NSPS. The cost model is used to calculate costs for each option based on the treatment technologies used as the basis for that option. These costs are estimates of actual compliance costs; however, the regulations do not require that a facility install or possess the technologies specified as the bases, but only that the appropriate limitations be met.

The Agency has selected a facility-by-facility approach to costing as opposed to a model facility approach, because of the variability of processes and resultant wastewaters among pharmaceutical manufacturing facilities. Detailed facility information was available from responses to the Detailed Questionnaire and comments on the proposed regulations, which was used to characterize the wastewater and assess existing treatment technologies at each facility. It should be noted, however, that in certain instances, engineering assumptions regarding facility operations were made, or industry average data were used when facility-specific information were not available. Thus, for any given facility, the costs estimated may deviate from those that would actually be experienced by the facility. However, since these assumptions were based on industry-wide data, the resulting estimates are considered accurate when evaluated on an industry-wide, aggregate basis.

When practical and appropriate, facilities were given credit for existing treatment on site, based on an evaluation of the following criteria:

- Biological treatment system aeration capacity (in million gallons);
- Clarifier overflow rate (in gallons per minute per square foot);
- Presence of adequate equalization treatment;
- Presence of steam stripping or steam stripping with distillation treatment that achieved adequate removal of organic compounds; and
- Presence of cyanide destruction treatment - this credit was given wholly or partially based on comparison to the treatment systems selected as the technology bases.

These treatment credits were used to develop cost estimates for system upgrades instead of new systems where appropriate. At facilities that currently meet the limitations associated with a regulatory option, no compliance costs beyond necessary additional monitoring were estimated.

10.2.1 Cost Model Structure

The model used to calculate wastewater treatment costs was developed based on research into various existing costing approaches and use of customized computer software tools. The model consists mainly of a series of technology modules, each of which calculates the costs associated with a particular treatment technology. These modules can be combined as appropriate to assemble each of the various regulatory options. A more detailed discussion of the cost model and its origins is given in Section 10.3.

Operation and maintenance (O&M) and capital costs were calculated by the model for each technology and then summed for all technologies at each facility. The facility capital and O&M costs were combined and totaled by subcategory and discharge type (e.g. Subcategory A and C - indirect discharger).

Annual O&M costs consist of all costs related to operating and maintaining the treatment system for a period of one year. Sources for O&M costs primarily included literature references and engineering judgement (typically used in the case of estimating required operator hours). O&M costs typically include the following:

- Chemical usage;
- O&M labor;
- Removal, transportation, and disposal of any waste solids, sludges, solvents, or other waste products generated by the treatment system; and
- Utilities, such as electricity and steam, required to run the treatment system.

Table 10-1 presents the O&M unit costs most commonly used by the model and includes references for the origin of each cost.

Capital costs consist of direct and indirect costs associated with purchase and installation of wastewater treatment equipment. Primary sources for the capital costs were vendor quotes and literature references. Table 10-2 presents the unit capital costs most commonly used by the model and includes references for the origin of each cost. Typically, direct capital costs include the following:

- Purchase and installation of treatment equipment;
- Purchase and installation of piping, instrumentation, pumps, and other ancillary equipment;
- Electrical hookups;
- Any required site preparation (e.g., excavation);
- Construction of buildings or other structures.

In addition to direct capital costs, indirect costs are also included in the estimate of total capital cost. Indirect capital costs typically include engineering costs and contractor's fees.

For each technology, it is assumed that ancillary direct capital costs and required indirect capital costs can be accounted for by using a factor related to purchased and installed capital cost. Table 10-3 lists these factors for all applicable treatment technologies.

Because all facility-specific information in the questionnaire database is from 1990, all costs are adjusted to 1990 dollars. This adjustment allows direct comparison between reported financial data and costs for each facility. Costs are adjusted using the Marshall and Swift 1990 annual index (915.1) and the index value for the year in which the costs were originally reported using the following formula:

$$AC = OC(915.1/OCI) \tag{10-1}$$

where:
AC = Adjusted cost, \$
OC = Original cost, \$
OCI = Original cost year index

The wage rate for all required labor to properly operate and maintain the systems associated with the technology bases was based on a weighted average, where data were obtained from two sources: (1) the U.S. National Bureau of Labor Statistics, and (2) industry supplied wage rates. In 1990, the U.S. National Bureau of Labor Statistics reported that the average wage rate for all production workers in the Drug Manufacturing industry was $12.90 per hour. This rate was then increased by 115% to account for supervision (15%), and overhead (100%) to arrive at a total rate of $27.74 per hour. This cost was assumed for the entire industry except where industry supplied wage rates. The weighted average wage rate for the entire industry was $27.89 per hour.

The cost for electricity used by various treatment technologies was obtained from two sources: (1) 1990 U.S. Department of Energy Statistics for Investor-Owned Utilities for Commercial Facilities and (2) industry supplied energy costs. The U.S. Department of Energy rate was given as $0.048 per kilowatt-hour. This cost was averaged with industry supplied costs for a rate of $0.059 per kilowatt-hour for facilities in the United States. The rate of $0.080 per kilowatt-hour for facilities in Puerto Rico was derived from an industry supplied rate.

The cost for steam usage was based on a weighted average, where data were obtained from two sources (1) Plant Design & Economics for Chemical Engineers, Peters and Timmerhaus, Fourth Edition, and (2) industry supplied steam costs. The unit cost obtained from source (1) was $3.20 per 1,000 pounds of 100 psig steam, and represents the high end of the range of costs given for 100 psig steam. This cost was assumed for the entire industry (U.S.) except where industry supplied steam costs. The weighted average steam cost for facilities in the United States was $4.20 per 1000 pounds of 100 psig steam. The steam cost of $6.91 per 1000 pounds of 100 psig steam for facilities in Puerto Rico was derived from industry supplied costs. These unit costs are listed along with other O&M unit costs in Table 10-1.

For the cost estimating effort, it was assumed that all Subcategory A and C facilities and Subcategory B and D direct discharger facilities operate 350 days per year, and that Subcategory B and D indirect discharger facilities operate 250 days per year. These assumptions are based on operating modes observed during engineering site visits. If a facility supplied the actual number of operating days per year, this number was used. It is also assumed, because of the nature of the technology, that all biological treatment systems operate 365 days per year, regardless of subcategory.

10.3 Cost Modeling

10.3.1 Evaluation of Existing Cost Models

Before a costing methodology could be developed, existing cost models were researched and evaluated to determine which, if any, existing algorithms for costing various treatment technologies could be used to develop costs for wastewater treatment systems and treatment system upgrades in the pharmaceutical manufacturing industry. The following models were initially considered for potential use:

- The Wastewater Treatment System Design and Cost Model (WTSDCM) developed by EPA in the early 1980s for various metal manufacturing-related industries;

- The Cost of Remedial Action model (CORA);

- The Remedial Action Cost Engineering and Requirements (RACER) model;

- The Advanced System for Process Engineering (ASPEN);

- The Computer Assisted Procedure for the Design and Evaluation of wastewater Treatment systems (CAPDET); and

- The pesticide industry models developed by EPA for pesticide chemicals manufacturers and pesticide formulators, packagers, and repackagers, respectively.

The WTSDCM model was eliminated because of the lack of similarity between pharmaceutical and metal manufacturing industry wastewaters and related treatment techniques. The CORA model was also eliminated because it had been superseded by the more recently developed RACER model. The remainder of the cost models were considered further.

The RACER model was determined not to be applicable because it was designed to address remedial treatment activities associated with cleanup of contaminated sites, and not industrial wastewater treatment. ASPEN was also determined not to be applicable because, while serving as an excellent process simulation tool, it is not set up to serve the cost estimating purposes required. It also models only the steam stripping treatment technology included in the basis for the regulatory options.

The remaining models (CAPDET and the pesticide industry models) were determined to have some appropriate design and costing information, but were not configured properly to be used directly to cost the pharmaceutical manufacturing industry. Based on this conclusion, it was determined that the most effective way to model costs for the industry would be through development of a new cost model.

The resulting cost model is an integrated computer model that uses design and costing information taken from many sources, including CAPDET and the pesticides industry models. The cost model includes program files that design and cost all technologies included as bases for the regulatory options discussed in 7, and data files that include all pertinent facility data.

10.3.2 Model Driver

Because the pharmaceutical manufacturing industry cost model (hereafter referred to as the cost model) is basically a collection of computer "modules" designed to calculate costs for each of the basic technologies, it was necessary to include a program to organize the modules and track the costs for the entire industry. This program has been designated as the model "driver". The model driver performs the following major functions associated with generating industry costs for each of the regulatory options:

- Locate and open all necessary input data files;
- Store input data entered by a user of the model;
- Open and run each of the technology modules in the appropriate order;

- Track all costs and pollutant concentrations generated by the technology modules; and

- Send tracked costs by subcategory, discharge type, and regulatory option to a storage file which may be printed or maintained in electronic form.

The following sections list the major technologies included as modules within the cost model, and describe the major assumptions and costing methodology used for each.

10.3.3 Advanced Biological Treatment

Advanced biological treatment is used to control BOD_5, COD, and TSS and to degrade various organic pollutants. The biological treatment systems are designed based on COD loads, or BOD_5 and TSS loads, and desired removal efficiency. Organic pollutant reduction also occurs through well-operated biological treatment systems. The installation of extended aeration activated sludge biological treatment was assumed for cost estimating purposes for BOD_5, COD, TSS and organics. For ammonia the installation of a second stage activated sludge nitrification system was assumed for cost estimating purposes. As shown in Table 7-1, activated sludge treatment is the most common biological treatment used in the pharmaceutical manufacturing industry. All of the facilities that form the bases for the limitations based on biological treatment use activated sludge biological treatment on site.

Typically, an extended aeration activated sludge biological treatment system consists of the following major equipment:

- An equalization basin;
- An aeration basin;
- A secondary clarifier; and
- A sludge handling system, if necessary.

10.3.3.1 Overview of Costing Methodology

Facilities requiring additional treatment of BOD_5, COD, TSS, or organics were costed for installing a biological treatment system capable of removing these pollutants down to the long-term mean performance concentrations for this technology that are discussed in 8.5. If a facility had no biological treatment on site, a new treatment system was costed. If a facility had biological treatment on site, an upgrade to the existing system was costed.

Various types of upgrades were possible for a facility with existing treatment on site. If additional BOD_5, COD, or organics removal was required, an additional aeration basin was installed in parallel with the existing treatment unit. If additional TSS treatment was also required, additional clarifiers were installed in parallel with the existing clarifiers. If the costed biological treatment system, whether an upgrade or new system, was determined to generate excess biological solids, a new sludge handling system was installed. If ammonia removal was required, an additional aeration basin was installed as a second stage nitrification system with clarifiers.

10.3.3.2 Design Bases and Assumptions

The design of the aeration basin for biological treatment of BOD_5, COD, TSS and organic pollutants, and secondary clarifier are based on a combination of relationships and equations developed by Eckenfelder and from field data for suspended growth biological treatment. The design of the aeration basin for biological treatment of ammonia through nitrification are based on relationships and equations developed by Metcalf and Eddy. Costing equations were taken from CAPDET for equalization basins, package extended aeration activated sludge units (facility flows less than 0.5 MGD), full-size extended aeration activated sludge units (flows greater than 0.5 MGD), and circular secondary clarifiers.

Design equations for biological treatment systems were similar for new units and for upgrades. The following is a list of key design assumptions for costing biological treatment for pharmaceutical manufacturing facilities:

- Values for key design parameters associated with biological treatment were established based on subcategory-specific information obtained from the Detailed Questionnaire Responses. These values are listed in Table 10-3.

- The retention time for designed clarifiers is 5 hours.

- The retention time for designed equalization basins is 24 hours (if a new equalization basin is necessary).

- The sludge generated by the biological treatment unit has the following characteristics:

  - 1% solids in the sludge from the clarifier to the sludge thickener;
  - 5% solids in the sludge from the thickener to the filter press;
  - 13% solids in filter press cake; and
  - Sludge density equal to 80 lbs/ft^3.

- Generated sludge is thickened, dewatered, and hauled off site for incineration as a nonhazardous waste.

- Installation of any of the equipment associated with biological treatment will not require purchase of additional land. In response to concern about this assumption, the agency solicited information from facilities documenting the need for the purchase of additional land for upgrades to their biological treatment system. Commenters which responded to the solicitation all have the land available on-site. Therefore, this assumption has been maintained.

- One or more floating surface mixers are necessary for operation of the equalization basin. (It is assumed that 30 horsepower per million gallons are required for mixing in the equalization basin.)

- Fix-mounted surface aerators will be used for treatment of BOD_5, COD, organics, and ammonia.

10.3.3.3 Costing Methodology

Cost equations for purchase and installation of equipment associated with equalization, aeration, and secondary clarification were obtained from CAPDET. The costs for the following standard-sized equipment were also obtained from CAPDET: package aeration plant (100,000 gal/day) and clarification tank (90-foot diameter). The following costs were obtained from vendors or costing references: chemical unit costs, excavation unit cost, reinforced concrete installation unit cost, floating surface aerator costs, fixed-mounted surface aerator costs, sludge thickening tank costs, sludge filter press costs, and sludge hauling and disposal costs. Tables 10-1 and 10-2 presents all unit costs listed above.

The following are included in the total capital cost calculated for each facility requiring biological treatment (all equipment costs include purchase and installation):

- A reinforced, concrete equalization basin (if not already existing at the facility);
- Floating surface mixers for the equalization basin, if necessary;
- A reinforced concrete aeration basin, with associated fixed-mounted surface aerators, if necessary (aeration basins are provided at facilities with no existing biological treatment, at those needing ammonia nitrification, or where existing treatment is not adequate);
- A reinforced concrete clarifier, if necessary (clarifiers are provided at facilities with no existing biological treatment, or where existing suspended solids removal is not adequate);
- Any earthwork required for site preparation prior to installing the equalization basin, aeration basin, or clarifier (earthwork includes the construction of curbs and dikes for secondary containment);
- A platform and pedestrian bridge over the aeration basin;
- Sludge thickening tank(s); and
- Filter press(es) for sludge dewatering.

Table 10-4 presents the factors that are used by the cost model to account for ancillary direct and all indirect capital costs.

The following are included in the total O&M costs calculated for each facility:

- O&M labor;
- Electricity usage;
- Chemical purchases;
- Miscellaneous O&M materials and supplies; and
- Sludge hauling and incineration.

Table 10-5 lists operation and maintenance labor hour requirements for various activities associated with biological treatment.

All operation and maintenance hour requirement calculations except those used for sludge handling were based on assumptions and equations from CAPDET. Sludge handling labor hour requirements were developed based on engineering judgement regarding the labor required for operation and maintenance of the filter press or presses.

Electricity usage was calculated using relationships provided in CAPDET. Table 10-6 presents the electricity requirement equations that are used by the cost model for each portion of the biological treatment system. Miscellaneous O&M material and supply costs are based on factors provided in CAPDET. Table 10-7 presents the operation and maintenance material and supply factors that are used by the cost model for biological treatment operations.

Table 10-1 lists unit costs for chemical purchases and sludge hauling and incineration.

10.3.4 Cyanide Destruction Treatment

There are two technologies that are used as the basis for cyanide destruction: hydrogen peroxide treatment and alkaline chlorination treatment. Hydrogen peroxide technology would be used by the majority of facilities while facilities with a potential safety hazard would be required to comply with limitations based on alkaline chlorination. Hydrogen peroxide destruction is used by Facility 30542 and represents the basis of the treatment performance data used by EPA to develop the limitation for cyanide for facilities currently using hydrogen peroxide destruction. The system designed and costed by the cost model has a greater degree of control than the system used by Facility 30542, in that laboratory analysis of treated batches of wastewater for cyanide is required prior to discharge. This approach minimizes the potential for releases of wastewater with cyanide concentrations above the proposed limitations. Facility 30542 currently uses a qualitative field technique to measure cyanide after treatment which does not provide the same level of precision and accuracy as the EPA-approved analytical method.

Alkaline chlorination is used by Facility 30567 and represents the basis of the treatment performance data used by EPA to develop the limitation for cyanide for facilities currently using alkaline chlorination or hydrolysis technologies. The equipment designed and costed is the same as that designed and costed for hydrogen peroxide destruction.

The cyanide destruction treatment system costed for the pharmaceutical manufacturing industry includes the following equipment: four pumps (influent, effluent, sodium hydroxide, and either hydrogen peroxide or sodium hypochlorite feed pumps), five tanks (pH adjustment, reactor, either hydrogen peroxide or sodium hypochlorite feed, sodium hydroxide feed, and treated wastewater storage), two agitators (for the reactor and pH adjustment tanks), and a pre-engineered building to house the treatment unit. If the required volumes of the chemical additives were less than 5.7 gal/day, 55-gallon drums are used for storage instead of storage tanks.

10.3.4.1 Overview of Costing Methodology

Costs for in-plant cyanide destruction treatment were included for all facilities that reported the presence of cyanide in their wastewater in the Detailed Questionnaire and who discharged in 1990 cyanide concentrations above the long-term mean treatment performance concentrations provided in 8. In-plant streams are defined as cyanide-bearing wastewater streams prior to dilution with non-cyanide-bearing wastewater. Facilities that had portions of the technology bases for this treatment already on site were given credit for these elements, and therefore did not incur costs associated with a complete, new treatment system.

10.3.4.2 Design Bases and Assumptions

Cyanide destruction treatment using hydrogen peroxide is based on the reaction of cyanide with hydrogen peroxide under basic conditions to form ammonia and carbonate ions. Cyanide destruction treatment using alkaline chlorination is based on the reaction of cyanide with sodium hypochlorite under basic conditions to form sodium chloride and carbonate ions. Facilities with high organic concentrations may not be able to use hydrogen peroxide oxidation because of potential safety hazards the reaction may cause. Components that comprise the treatment system were selected based on the system used by Facility 30542. The cost estimates generated by the cost model are based on the following treatment steps:

- Collection of the wastewater in the pH adjustment tank.
- Addition of sodium hydroxide to raise the pH in the tank.
- Transfer of wastewater to the reactor vessel.
- Addition of either hydrogen peroxide or sodium hypochlorite to the reactor to treat cyanide, followed by field cyanide analysis.
- If the batch fails the field analysis, it is reacted again with either additional hydrogen peroxide or sodium hypochlorite. If it passes, the wastewater is transferred to the storage tank for laboratory analysis.
- If the batch fails laboratory analysis, it is returned to the hydrogen peroxide reaction vessel for additional treatment. If it passes, it is discharged to the end-of-pipe treatment system (if applicable).

Costs for equipment and chemicals are based on vendor information.

The following key assumptions and design bases were used to cost cyanide destruction treatment:

- There is adequate land to install the treatment unit at each facility requiring cyanide destruction;
- All equipment is sized based on in-plant flow rate reported for waste streams containing cyanide; and

- Cyanide destruction treatment is operated in a batch mode, with up to three batches treated per day.

10.3.4.3 Costing Methodology

The treatment system components were chosen based on the system used by Facility 30542. Unit costs for the following were obtained from vendors or costing reference manuals: spill containment drum pallets, pumps, tanks, agitators, earthwork for building installation, pre-engineered building purchase and installation, chemical purchases, and laboratory and field monitoring. Tables 10-1 and 10-2 present these unit costs.

The following are included in the direct capital cost calculated for each facility requiring cyanide destruction treatment:

- Tanks for pH adjustment, reaction, storage of either hydrogen peroxide or sodium hypochlorite, storage of sodium hydroxide, and storage of treated wastewater prior to discharge;

- For smaller volumes (less than 5.7 gal/day), 55-gallon drums to store chemicals used for cyanide destruction, instead of tanks (if drums are used, drum spill containment pallets are included);

- Pumps for delivering influent wastewater to the system, removing effluent from the system, delivering either hydrogen peroxide or sodium hypochlorite to the reaction tank, and delivering sodium hydroxide to the pH adjustment tank;

- Agitators in the reaction and pH adjustment tanks;

- Earthwork to prepare the site for installation of a pre-engineered building (earthwork includes the construction of curbs and dikes for spill containment); and

- A building to house the cyanide destruction treatment system.

Table 10-4 presents the factors for calculating ancillary direct and all indirect capital costs.

The following are included in the total O&M costs calculated for each facility:

- O&M labor (assumed to be 1 hour per day);
- Materials and supplies;
- Chemical purchases;
- Field monitoring for cyanide concentration;
- Laboratory monitoring for cyanide concentration; and
- Electricity usage.

Maintenance material and supply costs are calculated based on the following relationships to installed equipment costs: 1% is used for pumps, 2% is used for storage tanks, and 5% is used for reaction tanks and agitators. Maintenance of pumps is also assumed to require one hour per day of operator labor.

Field and laboratory monitoring are assumed to occur once per batch for cyanide destruction treatment. Table 10-1 lists unit costs for cyanide monitoring. Electricity costs are based on pump usage.

10.3.5 Steam Stripping

Steam stripping is used to treat organic pollutants and ammonia in wastewater. In a steam stripping column, the wastewater to be treated is introduced near the top of the column and is allowed to flow downward through the column by gravity. Steam is simultaneously introduced at the bottom of the column, and flows countercurrently to the wastewater. In steam stripping columns, organic compounds and ammonia enter the vapor phase as the steam contacts the wastewater, and are carried out of the top of the column with the steam. The column overheads are condensed from vapor to liquid. A portion of the condensed overheads are returned to the top of the column as reflux, the remaining portion is disposed of off-site. If the condensed overheads form an aqueous and organic layer, a decanter is used so that the portion returned to the column is the aqueous layer, while the portion disposed of is the organic layer. Treated wastewater exits the column from the bottom.

The following equipment is assumed to be required to perform steam stripping: stripping column, feed preheater/bottoms cooler, steam condenser, subcooler, decanter, air pollution control device, feed collection and storage tank, distillate receiver tank, feed pump, reflux pump, distillate pump, bottoms pump, spare pump, piping, and instrumentation. Multiple units may be required for any or all of the equipment listed above, due to high facility flow rates or if multiple process streams requiring steam stripping exist at a facility. The air pollution control device is costed as an acid scrubber if ammonia is present in the waste stream; otherwise it is costed as a carbon canister. Facilities may find that it is cost effective to route vents from the steam stripper unit to an existing incinerator or other air pollution control system. This approach was not costed as part of this effort because information on existing air pollution control systems was not available.

10.3.5.1 Overview of Costing Methodology

Data supplied by the pharmaceutical industry to EPA's Office of Air Quality Planning and Standards (OAQPS) were used to develop assumptions regarding facility process wastewater stream flow and load distributions. Every facility was assigned four theoretical waste streams. Relative flows and stream loads are consistent among all facilities. Stream 1 for each facility represents 44 percent of the total facility wastewater flow as reported in the Detailed Questionnaire, and it comprises 1 percent of its total pollutant load (in pounds). Stream 2 represents 9 percent of the flow, and comprises 2 percent of the total pollutant load. Stream 3 represents 19 percent of the flow, and 6 percent of the total load. Stream 4 represents 28 percent of the total flow, and contains 91 percent of the pollutant load.

Facilities were costed for steam stripping of all process wastewater streams with concentrations of regulated pollutants above the long-term mean treatment performance concentrations for the steam stripping options, provided in 8. Cost estimates are based on the installation of the technology at an in-plant location. An in-plant location is defined as prior to dilution by non-process wastewater, commingling with other process wastestreams not containing regulated pollutants at treatable levels, and any conveyance, equalization, or other treatment units which are open to the atmosphere.

Facilities were given credit for steam stripping on site if an existing column was used to treat organic pollutants in wastewater to concentrations below the long-term mean treatment performance concentrations for steam stripping. If steam stripping treatment existed on site that did not treat organics to these levels, effluent from the existing column was considered as influent to the new column to be costed. It may be possible for facilities to improve performance of existing steam stripping columns to meet the required levels. However, the facility-specific information provided in responses to the Detailed Questionnaire was not adequate to determine if this would be possible for individual cases. Therefore, new columns were costed for all facilities not meeting the long-term mean treatment performance concentrations. The modeled compliance costs for facilities able to optimize their existing steam stripping column performance will be higher than actual compliance costs.

Facilities were also given credit for steam strippers to be put in place to meet the upcoming maximum achievable control technology (MACT) standards. These strippers were assumed to be in place on streams that EPA's Office of Air Quality Planning and Standards (OAQPS) deemed cost effective. If these strippers could treat organic pollutants in wastewater to concentrations below the long-term mean treatment performance concentrations, no additional steam strippers were costed. Otherwise, steam strippers were costed to treat the effluent from the OAQPS strippers down to the long-term mean treatment performance concentrations, provided in 8.

10.3.5.2 Design Bases and Assumptions

The steam stripping systems designed and costed by the cost model are based on achieving sufficient treatment of the least strippable compound present in the process wastewater stream being treated. Strippability groups were created for the purpose of establishing the design bases for steam stripping treatment. The strippability groups contain all regulated compounds and range from most easily stripped (Group 1) to not strippable at all (Group 8). Table 10-8 lists all potentially regulated compounds by these strippability groups.

The least strippable compound is selected for a particular stream based on the following criteria:

- Only compounds with concentrations above the steam stripping long-term mean treatment performance concentration are considered;
- Only compounds in the least strippable group (excluding the nonstrippable group) of any compounds at the facility are considered; and
- Within the least strippable group, the compound with the lowest Henry's Law Constant is selected.

Design parameters for the steam stripping column are selected based on the least strippable compound and its concentration in the process wastewater to be treated. Key steam stripping design parameters are:

- K value - the volatility or equilibrium ratio for a contaminant in a vapor/liquid system at the temperature and pressure of the column.
- Number of equilibrium stages - the number of contact units in a column within which the concentration of components in the liquid phase is in equilibrium with the concentration of components in the vapor phase.
- Steam-to-feed ratio - the volume of steam required to treat a given volume of wastewater.

Table 10-9 lists the steam stripping design parameters for constituents in Groups 1 through 7 (no values are given for compounds in Group 8 because they are not considered treatable by steam stripping).

Process simulations were used to assist in establishing the cost module design basis in two ways:

1. Process simulations were used to develop process designs that would achieve the long-term steam stripping performance levels for each of the strippability groups, typical numbers of equilibrium stages and feed/steam (L/V) ratios were determined using process simulations discussed in 8 for pollutants in each of the strippability groups; and

2. Simulations were also used to help estimate a typical K value for pollutants in each strippability group.

The model scans all pollutants in each stream at each facility for strippability group and for concentration. If any regulated pollutants are above the steam stripping long-term mean treatment performance concentration and are considered strippable, then treatment is costed for the stream. EPA evaluated each of the four process desegregated streams separately; therefore, a facility might have four steam stripping systems costed. The largest allowable diameter column designed by the model is 15 feet. This limitation is based on the difficulty associated with transporting larger columns. If a column larger than 15 feet is required, multiple columns are costed.

It is assumed that facilities requiring steam stripping treatment will have adequate space within existing enclosed process buildings.

10.3.5.3 Costing Methodology

Design equations were obtained from engineering texts, ASPEN methodology, and input from design engineers. Most unit costs were obtained from algorithms found in Peters and Timmerhaus, Fourth Edition (12). Others were obtained from vendor quotes. Unit costs were included in the cost model for the following: packed and tray columns, storage tanks, condensers, decanters, subcoolers, pumps, air pollution control devices, and feed preheaters. These unit costs were developed using algorithms dependent on multiple variables, and are presented in the Pharmaceuticals Manufacturing Industry Cost Documentation Report, which can be found in the Administrative Record of this rulemaking. Table 10-10 provides the purchase costs for the smallest and largest size of each major component of the steam stripping treatment unit, as designed and costed for all pharmaceutical manufacturing facilities that responded to the Detailed Questionnaire.

These costs are for individual components only, some systems may require the installation of multiple components. Pump costs and chemical additive costs were obtained from vendor quotes. These unit costs are presented in Tables 10-1 and 10-2.

The following are included in the total capital cost calculated for each facility requiring steam stripping treatment:

- Stainless steel column(s), including either packing or trays (packing was used for columns with diameters less than 48 inches; trays were used for larger diameter columns);

- Stainless steel feed preheater(s)/bottoms cooler(s) to prepare influent wastewater for treatment and to maintain an acceptable temperature in the effluent from the column;

- Stainless steel steam condenser(s)/subcooler(s) to convert overheads from vapor to liquid;

- Decanter(s) to separate distilled organic compounds from water to be returned to the column;

- Air pollution control device(s) to remove noncondensible organics or ammonia from the vent stream;

- Stainless steel feed collection and storage tanks with capacity to 24 hours;

- Stainless steel distillate collection tank with capacity to 24 hours; and

- Pumps to deliver influent wastewater to the column, refluxed wastewater back to the column inlet, effluent bottoms to storage tank, distillate to collection tank, and sodium hydroxide to the feed storage tank if pH adjustment is necessary (pH adjustment is required for streams that contain ammonia; stripping is performed at a pH of 9 for ammonia-bearing streams).

Stainless steel components were costed because of the corrosion potential of pharmaceutical manufacturing wastewater. Hastelloy was considered as a construction material, and may be necessary on a site-specific basis. However, for the purpose of calculating industry-wide costs, stainless steel was considered the most appropriate construction material.

Table 10-4 lists the factors that are used by the model to account for ancillary direct and all indirect capital costs.

The following are included in the O&M costs calculated for each facility:

- O&M labor;
- Steam usage;
- Chilled water usage for the condenser and subcooler;
- Hydrochloric acid addition to the ammonia scrubber (if necessary) or carbon canister replacement for air pollution control;
- Sodium hydroxide addition, if pH adjustment is necessary;
- Hauling and disposing of waste hydrochloric acid (if any) and waste solvents decanted from the column overhead stream;
- Miscellaneous O&M materials and supplies (assumed to be equal to 4% of the total capital cost); and
- Electricity usage.

O&M labor requirements are based on 12 labor hours per day to properly operate and maintain the steam stripping unit. Steam usage is calculated based on the facility flow rate and the selected steam-to-feed ratio.

Hydrochloric acid usage in the ammonia scrubber is calculated based on the amount of ammonia in the overhead stream from the column. It is assumed that 20% of the ammonia removed from the waste stream will be vented to the air pollution control device, and that the mass (pounds) of hydrochloric acid required will be 2.12 times the mass of the removed ammonia. The value 2.12 is based on the reaction of hydrochloric acid with ammonia in the air pollution control device. Carbon canister usage is based on the total mass of organic compounds removed from the waste stream. Based on ASPEN simulations, it is assumed that 0.29% of the overheads from the column will be vented to the air pollution control device. Based on EPA data from air emission studies at Superfund sites, it is assumed that 10 pounds of carbon will be required for each pound of organics removed in the air pollution control device.

Sodium hydroxide usage is calculated based on the presence of ammonia in the waste stream and the flow rate of the stream. Hauling and disposing of waste hydrochloric acid and waste solvents is based on unit costs displayed in Table 10-1. Electrical usage is calculated based on pump usage and pump horsepower.

10.3.6 Contract Hauling

Cost estimates for contract hauling of wastewater were developed for facilities with low flows. The treatment consists of storing untreated wastewater at the current end-of-pipe discharge point, and then hauling it off site for incineration. It has been determined that this approach is more cost-effective than other in-plant or end-of-pipe treatments for flows below 30 gallons per day.

The equipment required to perform this treatment depends on whether drums or a storage tank are used to store the wastewater. For drum storage, the only equipment required is the drums. If a storage tank is used, the equipment includes the tank and a discharge pump. It is assumed that for each scenario, the facility will have enough existing space for wastewater storage, requiring no additional land or facility improvement costs.

10.3.6.1 Overview of Costing Methodology

No credit was given to facilities for existing treatment on site. It was assumed that contract hauling would be performed at facilities with discharge flows below 30 gal/day and regulated pollutants at concentrations above the long-term mean treatment performance, regardless of the existing level of treatment.

10.3.6.2 Design Bases and Assumptions

The following assumptions were made for costing contract hauling:

- Facilities with zero wastewater discharge, no regulated pollutants reported, or no concentrations of regulated constituents above limitations did not incur any costs.
- Wastewater from all facilities requiring contract hauling required incineration.
- Any facility with a flow rate greater than 30 gal/day was not considered.
- The incineration facility was assumed to be 500 miles from the generating facility.

The selection of drums versus a storage tank for on site storage prior to disposal is based on the on-site storage time required to generate 5,000 gallons of wastewater. If it takes longer than 45 days to accumulate 5,000 gallons on site (approximately 110 gal/day), drums are used to store the wastewater. If it takes less than 45 days to generate 5,000 gallons, a storage tank is used instead.

Spill prevention for the drum storage system is provided by including spill prevention drum pallets for the storage area. These pallets provide a contained space beneath the drums to collect any leakage or spills.

10.3.6.3 Cost Methodology and Assumptions

Required costs for the following were obtained from vendor information: tanks, pumps, hauling, incineration, drums, and spill prevention pallets. Tables 10-1 and 10-2 present these unit costs.

The following were included in the total capital cost for each facility requiring contract hauling:

- Storage tank purchase and installation, if necessary (assumed to be an 11,000-gallon tank); and

- Discharge pump purchase and installation (assumed to be a 70-gpm pump), if necessary.

The following items are included as O&M costs for contract hauling:

- Drum purchase, if necessary;
- Spill prevention pallet purchase, if necessary;
- Electricity requirements for the pump, if necessary;
- Tank or drum area daily inspection (15 minutes per day);
- Loading and unloading of wastewater for transport;
- Transport of wastewater to the disposal facility (assumed to be 500 miles); and
- Incineration of the wastewater.

10.3.7 Compliance Monitoring

Compliance monitoring costs were calculated for all pharmaceutical manufacturing facilities that discharge wastewater. Costs represent analytical analysis costs based on which pollutants were reported in 1990 to be discharged in a facility's wastewater. Monitoring is required at the end of pipe for all regulatory options.

Costs for monitoring the discharge levels of BOD_5, COD, and TSS have not been included, as no incremental costs above those which the plants are presently incurring are anticipated. Cyanide monitoring costs are included as part of the cyanide treatment cost module and are not calculated in the monitoring module. It is assumed that no additional physical equipment is required to perform monitoring.

10.3.7.1 Overview of Costing Methodology

For purposes of estimation, facilities were costed for weekly end-of-pipe (EOP) monitoring for compounds that were reported in 1990 to be discharged in a facility's wastewater, and one annual EOP full analytical scan for all regulated pollutants. Permit writers or pretreatment authorities will determine the frequency of monitoring on a per facility basis. All facilities will be required to perform the annual EOP full analytical scan.

10.3.7.2 Cost Methodology

There are no capital items associated with compliance monitoring. The only O&M costs included for this activity are the laboratory analytical costs. It is assumed that the labor required to perform monitoring sampling is negligible compared to labor requirements already existing at each facility. It is also assumed that any materials required for monitoring are already present at the facility or are provided by the laboratory performing the analyses. All analytical cost information was provided by vendors of analytical services.

10.4 Engineering Costs by Regulatory Option

Table 10-11 presents a summary of estimated BPT, BCT, BAT, and PSES engineering costs, broken down by subcategory, discharge type, and regulatory option. Costs shown include capital and operation and maintenance (including energy usage) costs totaled for each group of applicable facilities.

It should be noted that advanced biological treatment costs are incorporated into both the BPT and BAT costs for direct dischargers. Facilities would install only one treatment system adequate to comply with both BPT and BAT limitations.

Table 10-12 presents a summary of estimated NSPS and PSNS engineering costs on an amortized yearly basis.

For NSPS and PSNS, costs were developed using the existing facility information to model potential new source facilities. NSPS and PSNS costs were developed on an annualized basis using amortized yearly costs and assuming a Subcategory A and/or C facility flow rate of 1 MGD and a subcategory B and/or D facility flowrate of 0.1 MGD.

The amortized yearly costs are equal to the sum of amortized capital costs and the yearly operation and maintenance costs. The capital costs are amortized using the following equation:

$$\text{Amortized Capital Cost (\$/yr)} = \text{Capital Cost (\$)}\left[\frac{i\,(1+i)^n}{(1+i)^n - 1}\right]$$

where: I = Interest rate of .07

n = Equipment depreciation period of 16 years.

Table 10-1

Operation and Maintenance Unit Costs Used By the Cost Model

Unit Disposal Costs			
Activity	**Cost (1990 $)**	**Units**	**Reference**
Incinerate drums of liquid waste	480.10	55-gallon drum	2
Dispose of bulk wastewater	5.02	gallon	2
Incinerate solvents in bulk	280.00	ton	3,4,36
Incineration of waste HCL	280.00	ton	4
Dispose of biological treatment sludge	50.00	ton	5 (a)
Unit Hauling Costs			
Activity	**Cost (1990 $)**	**Units**	**Reference**
Haul solvents	29.02	ton	4
Haul drums/bulk wastewater	2,626.00	full load (80 drums or 5,000 gallons bulk liquid)	2
Haul biological treatment sludge	4.05	loaded mile	6
Unit Chemical Costs			
Chemical	**Cost (1990 $)**	**Units**	**Reference**
NaOH (50%)	310.00	ton	7
H_2O_2 (50%)	0.495	pound	7
NaOCL (10%)	1.17	gallon	35
Nitrogen (Ammonium Sulfate)	0.013	pound	7
Phosphorous (Phosphoric Acid)	0.199	pound	7
Hydrochloric acid	395.77 - 482.65	drum (500 lbs)	8
Polymer	2.25	pound	9
Miscellaneous Unit Costs			
Item	**Cost (1990 $)**	**Units**	**Reference**
O&M labor rate	27.89	hour	10, 37
Electricity usage fee (US/PR)	0.059/0.080	kilowatt-hour	11, 37
Steam (US/PR)	4.20/6.91	1000 lbs	12, 37

Table 10-1 (Continued)

Miscellaneous Unit Costs			
Item	**Cost (1990 $)**	**Units**	**Reference**
Sample fee (for off-site disposal)	322.22	per load of wastewater	2
Drum purchase	43.66	drum	13
Field cyanide analysis	0.50	per sample	14
Laboratory cyanide analysis	27.50	per sample	15

(a) Unit cost was calculated by taking the median of costs reported by pharmaceutical manufacturing facilities for disposing of similar wastes.

Table 10-2

Capital Unit Costs Used by the Cost Model

Construction Unit Costs			
Activity	**Cost (1990 $)**	**Units**	**Reference**
Excavation	4.81	cubic yard	16
Concrete wall installation	547.69	cubic yard	17
Concrete slab installation	120.51	cubic yard	18
Prefabricated building installation	19.51	square foot of floor space	18
Impermeable, double liner installation	3.58	square foot	19
Crane rental	98.15	hour	20
Handrail installation	46.91	linear foot	21
Purchased, Installed Treatment Equipment Unit Cost			
Item	**Cost (1990 $)**	**Standard Size**	**Reference**
Package biological treatment plant	67,944	100,000 gal/day	22
Clarifier	139,610	90 ft diameter	22
Filtration unit	307,143	784 ft^2 of filter surface area	22
Fix-mounted surface aerator	33,080	20 HP	22
Pump station pump (large applications)	32,110	3,000 gpm	22
Filter press (1 ft^3 to 20 ft^3)	6,119 to 30,992	per press	23
Sludge Thickening Tank (100 gal to 500,000 gal)	1,270 to 79,062	per tank	24
Miscellaneous Unit Capital Costs			
Activity/Item	**Cost (1990 $)**	**Units/Standard Size**	**Reference**
Drum pallet (spill preventative)	338.64	4-drum pallet	25
Monitoring well installation	4,444	per well	26

Table 10-2 (Continued)

Miscellaneous Unit Capital Costs			
Activity/Item	**Cost (1990 $)**	**Units/Standard Size**	**Reference**
Groundwater background concentration determination	114,868	per acre of polishing pond	27
Unit Capital Costs Using Curves or Ranges			
Item/Activity	**Range/Equation**	**Units**	**Reference**
Small pumps (3 - 27 gpm)	Cost = 45.705 (Q) + 615.24 (Q= flow in gpm)	per pump	27
Larger pumps (50 - 900 gpm)	Cost= 6.09 (Q) + 2,485 (Q = flow in gpm)	per pump	23
Carbon steel tanks (11,000 to 150,600 gal)	Cost = 0.1935(V) + 8814 (V = volume in gallons)	per tank	28
Floating aerators (20 HP to 100 HP)	11,698 to 42,662	per aerator	29
Package filtration unit (SA < 400 ft^2)	Cost = $60,034(SA)^{0.3203}$ (SA = filter surface area in square feet)	per filter unit	22
Reaction vessel agitator (0.25 to 5.0 HP)	1,210 to 2,614	per agitator	30

Table 10-3

Constants and Values Used to Model Biological Treatment

Parameter	Subcategory A and C Value	Subcategory B and D Value	Units
Temperature	24.56	24.56	°C
Synthesis oxygen coefficient Influent VSS/TSS ratio	1.05	1.05	lb O_2/lb BOD_5
Nondegradable influent VSS	0.65	0.65	NA
Clarifier hydraulic loading Clarifier solids loading	0.70	0.70	NA
Clarifier polymer addition	400	400	gal/day/ft^2
Field oxygen transfer Substrate removal rate	20	20	lb/day/ft^2
constant (K)	1.5	1.5	mg/L
Synthesis yield coefficient	3.0	3.0	lb/HP-hr
Endogenous decay rate constant	11.14	2.06	NA
BOD_5 associated with effluent TSS	0.36	0.78	NA
	0.0	0.0	NA
COD removed to BOD_5 removed ratio			
	0.23	0.24	mg/mg
	0.615	0.52	NA

NA - Not applicable.
Source: Mean values based on information provided in the Detailed Questionnaire.

Table 10-4

Factors Used To Calculate Indirect and Ancillary Direct Capital Costs As a Percentage of Total Purchased and Installed Capital Cost

Technology	Factor (%)	Reference
Equalization	5	22
Package aeration (flow $\leq$ 0.5 MGD)	11	22
Full-size aeration (flow > 0.5 MGD)	11	22
Clarification	18	22
Cyanide destruction	35	31
Steam stripping	62.5	12

Table 10-5

Operation and Maintenance Labor Hour Calculations for Biological Treatment

Activity	Type of Labor	Minimum hours (per year)	Equation(s) for calculating hours per year
Package aeration	Operation	1200	$1683\ (FLOW)^{0.1469}$
	Maintenance	640	$1143\ (FLOW)^{0.2519}$
Full-size aeration	Operation	NA	$242.4\ (TICA)^{0.3731}$ $(TICA < 200)$ $100\ (TICA)^{0.5425}$ $(TICA \geq 200)$
	Maintenance	NA	$106.3\ (TICA)^{0.4031}$ $(TICA < 100)$ $42.6\ (TICA)^{0.5956}$ $(TICA \geq 100)$
Clarification	Operation	350	$37.1(SA)^{0.3247}$ $(1{,}000 \leq SA \leq 3{,}000)$ $4.0\ (SA)^{0.6020}$ $(SA > 3{,}000)$
	Maintenance	200	$30.3\ (SA)^{0.2733}$ $(1{,}000 \leq SA \leq 3{,}000)$ $2.05\ (SA)^{0.6098}$ $(SA > 3{,}000)$
Sludge Handling	Operation	NA	1 hour per batch per press for presses $< 6\ ft^3$ 2 hours per batch per press for presses between $6\ ft^3$ and $12\ ft^3$ 3 hours per batch per press for presses larger than $12\ ft^3$ The maximum number of operation hours per day at any one facility is 27.
	Maintenance	NA	2 hours per year per press

FLOW - Facility end-of-pipe wastewater treatment flow (MGD).
TICA - Total installed capacity of aeration (horsepower).
SA - Clarifier surface area (ft^2).
NA - Not applicable.

Table 10-6

Electricity Requirement Equations for Biological Treatment

Activity	Electricity Usage Equation (a)	
Package aeration	75,000 (FLOW)	
Full-scale aeration	6701.4 (TICA) (b)	
Clarification	7500 2183.3 $(SA)^{0.1663}$ 38.4 $(SA)^{0.5818}$	$(SA \leq 1670)$ $(1670 < SA \leq 16{,}700)$ $(SA > 16{,}700)$
Sludge Handling	None	

(a) All equations yield values in kilowatt-hours.
(b) This equation represents operating aerators 90% of the time, every day, year-round.
FLOW - Facility flowrate (MGD).
TICA - Total installed capacity of aeration (horsepower).
SA - Clarifier surface area (ft^2).

Table 10-7

Operation and Maintenance Material and Supply Cost Factors for Biological Treatment

Activity	Miscellaneous O&M Cost
Package aeration	$1.74\ (\text{FLOW})^{-0.2497}$
Full-size aeration	4.225 - 0.975log (TICA)
Clarification	1 percent of total clarification purchased and installed equipment costs

FLOW - Facility flowrate (MGD)
TICA - Total installed capacity of aeration (horsepower)

Table 10-8
Steam Stripping Strippability Groups for All Regulated Compounds

Compound	Strippability Group	Compound	Strippability Group
n-Heptane	1	Acetone	5
n-Hexane	1	Amyl alcohol	5
Benzene	3	2-Butanone (MEK)	5
Chlorobenzene	3	tert-Butyl alcohol	5
Chloroform	3	N,N-Dimethylaniline	5
o-Dichlorobenzene	3	Formamide	5
1,2-Dichloroethane	3	Isopropanol	5
Isopropyl Ether	3	Methyl Formate	5
Methyl Cellosolve	3	MIBK	5
Methylene Chloride	3	Ethanol	6
Toluene	3	n-Propanol	6
Xylenes	3	Aniline	7
Ammonia	4	n-Butyl alcohol	7
n-Amyl Acetate	4	1,4-Dioxane	7
n-Butyl Acetate	4	Pyridine	7
Diethylamine	4	Methanol (Methyl alcohol)	7
Ethyl Acetate	4	Petroleum naphtha	7
Isobutyraldehyde	4	Acetonitrile	8
Isopropyl Acetate	4	N,N-Dimethylacetamide	8
Tetrahydrofuran	4	N,N-Dimethylformamide	8
Triethylamine	4	Dimethyl sulfoxide	8
		Ethylene glycol	8
		Formaldehyde	8
		Phenol	8
		Polyethylene glycol 600	8

Table 10-9

Steam Stripping Design Parameters Established by Strippability Group

Strippability Group	Concentration of Least Strippable Contaminant	K Value	Number of Equilibrium Stages	Feed-to- Steam Ratio
1	ALL	10,219	4	12.0
2	ALL	1874.2	4	12.0
3	ALL	400	6	12.0
4	< 2,000	44.5	8	12.0
	> 2,000	44.5	10	12.0
5	≤ 1,000	21.6	10	12.3
	1,000 < conc. ≤ 5,000	21.6	14	12.9
	5,000 < conc. ≤ 10,000	21.6	14	12.1
	10,000 < conc. ≤ 50,000	21.6	14	10.9
	> 50,000	21.6	14	9.7
6	< 1,000	11.5	14	12.0
	1,000 < conc. ≤ 5,000	11.5	14	8.8
	5,000 < conc. ≤ 10,000	11.5	14	7.9
	> 10,000	11.5	14	6.8
7	< 5,000	7.8	14	7.8
	5,000 < conc. ≤ 10,000	7.8	14	6.3
	10,000 < conc. ≤ 20,000	7.8	14	5.5
	20,000 < conc. ≤ 30,000	7.8	14	5.1
	> 30,000	7.8	14	4.6
8	NA	NA	NA	NA

conc. - Concentration in mg/L.
ALL - Compounds in Groups 1, 2, and 3 are considered very strippable; therefore, all expected influent concentrations can be treated to limitations using the design criteria listed.
NA - Compounds in Group 8 are not considered strippable; therefore, no design parameters are listed.

Table 10-10

Purchase Cost Range for the Major Component of the Steam Stripping Treatment Unit

Component	Smallest Unit		Largest Unit	
	Cost	Size	Cost	Size
Packed Column	\$17,552	Diameter = 10 in.	\$141,724	Diameter = 32 in.
Tray Column	\$67,710	Diameter = 14 in.	\$208,528	Diameter = 35 in.
Condenser and Subcooler	\$4,430	Surface area = 52 ft^2	\$34,439	Surface area = 1,327 ft^2
Decanter	\$1,763	Volume = 8.2 ft^3	\$8,284	Volume = 210.3 ft^3
Acid Scrubber	\$16,507	Diameter = 10 in.	\$16,507	Diameter = 10 in.
Feed Preheater	\$3,583	Surface area = 21.4 ft^2	\$24,245	Surface area = 900 ft^2

Table 10-11

Summary of BPT, BCT, BAT, and PSES Engineering Costs

Regulation	Option	Subcategory A and C Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)	Subcategory B and D Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)
BPT	No Revision (MACT Only)	Current Treatment Technology	0	0	Current Treatment Technology	0	0
	Clarify cyanide, revise COD only	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	2,422,401	1,825,252	Advanced Biology Treatment Withdraw Cyanide	1,785,771	966,863
	Clarify cyanide and revise BOD, TSS, & COD	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	2,402,354	1,936,759	Advanced Biology Treatment Withdraw Cyanide	3,318,455	1,226,850
	Clarify cyanide and revise BOD, TSS, & COD	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	2,878,502	2,292,158	Advanced Biology Treatment Withdraw Cyanide	3,839,905	1,400,438
BCT	No Revision	Current BPT	0	0	Current BPT	0	0
	Revise BOD & TSS	Advanced Biological Treatment	2,402,354	1,936,759	Advanced Biological Treatment	3,318,455	1,226,850
	Revise BOD & TSS	Advanced Biological Treatment and Effluent Filtration	9,572,354	2,896,759	Advanced Biological Treatment and Effluent Filtration	5,689,455	1,461,850
	Revise BOD & TSS	Advanced Biological Treatment and Polishing Pond	25,072,354	16,436,759	--	--	--
	Revise BOD & TSS	Advanced Biological Treatment and Effluent Filtration Polishing Pond	31,872,354	19,036,759	--	--	--
BAT	Revise COD to BPT Limits and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	0	0	Advanced Biological Treatment and Withdraw Cyanide	0	0
	Add Organics Only, Revise COD to BPT Limits and Clarify Cyanide	Advanced Biological Treatment and Revised Monitoring Requirements for Cyanide	1,440,154*	1,775,563*	Advanced Biological Treatment and Withdraw Cyanide	887,021*	248,325*
	Add Organics and Ammonia, Revise COD to BPT Limits, and Clarify Cyanide	Advanced Biological Treatment with Nitrification, and Clarify Cyanide	5,569,135	2,423,725	***Ammonia limits do not apply for B/D facilities***	NA	NA

Table 10-11 (Continued)

Regulation	Option	Subcategory A and C Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)	Subcategory B and D Facilities	Capital Cost ($/yr)	O&M Cost ($/yr)
PSES	No Revision (MACT Only) and Clarify Cyanide	Current Treatment Technology and revised monitoring requirements for Cyanide	0	0	Current Treatment Technology and Withdraw Cyanide	0	0
	Organics Only and Withdraw Cyanide	***This option was not considered for A/C facilities***	NA	NA	In-Plant Steam Stripping for Organic Compounds and Withdraw Cyanide	17,880,239	4,643,632
	Organics and Ammonia, and Clarify Cyanide	In-Plant Steam Stripping for Organic Compounds and Ammonia (and revised monitoring requirements for Cyanide (nitrificationing be used for ammonia))	80,864,749	28,597,243	***Ammonia and Cyanide limits do not apply for B/D facilities***	NA	NA
	Organics and Ammonia and Revise Cyanide	In-Plant Steam Stripping for Organic Compounds and ammonia and in-plant cyanide destruction (nitrification may be used for ammonia)	81,192,219	28,839,569	***Ammonia and cyanide limits do not apply for B/D facilities***	NA	NA

* Costs for this option were calculated based on the list of pollutants considered for regulation, rather than the list selected for regulation. Actual costs would be slightly less due to reduced monitoring requirements.

Table 10-12

Summary of NSPS and PSNS Engineering Costs

Regulation	Option	Subcategory A and C Facilities	Annualized Cost ($/yr)	Costs at Set Flowrate (MGD)	Subcategory B and D Facilities	Annualized Cost ($/yr)	Costs at Set Flowrate (MGD)
NSPS	Revise Equal to Promulgated Level of BPT/BAT	Advanced Biological Treatment with Nitrification, and Revised Monitoring Requirements for Cyanide	$225,189	1	Advanced Biological Treatment	$70,218	0.1
PSNS	Revise Equal to Promulgated PSES Limits	PSES Treatment Technology	$1,620,852	1	PSES Treatment Technology	$306,300	0.1

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